Transportation Energy Evolution Modeling (TEEM) Program

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Project #: van021

Introduction

❑ Project Objectives

The goal of the TEEM project is to provide a suite of sales dynamics models to support techno-economic evaluation of VTO technologies. Understanding technology impacts requires structural understanding of market response. Modeling endogenous adoption is a critical linkage between technology R&D needs and impacts. By applying established decision science theories, sales dynamics models are a critical tool for analyzing VTO technology impact and generating insights for technology R&D activities.

The development objectives of these models include the following:

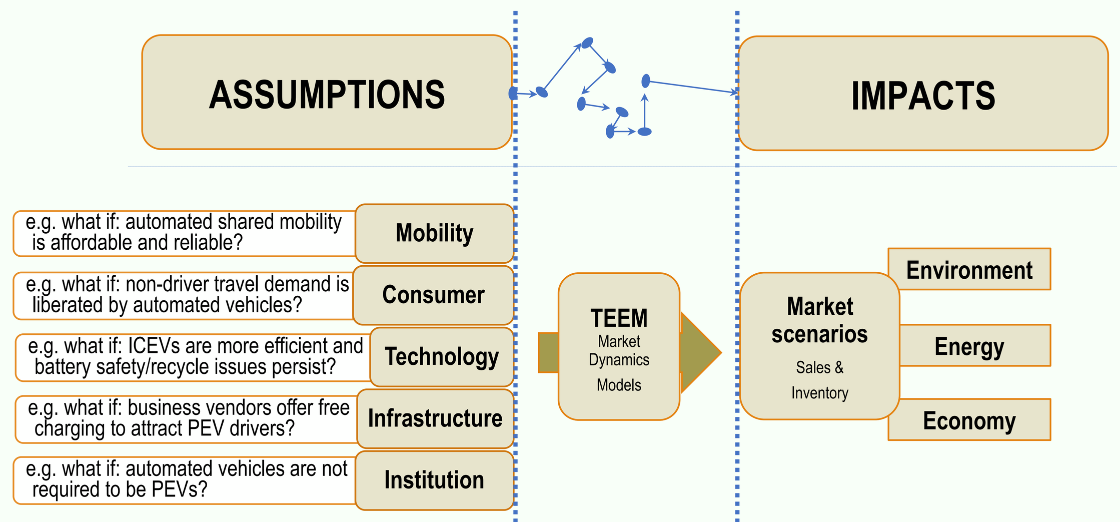
- **Technology scope** of the U.S. LDV/non-LDV/private/commercial-vehicle technologies, shared mobility and connected and automated vehicles.
- **Relevance** to VTO's technological and institution interests.
- **Comprehensiveness** in considering behavior, technology, and infrastructure factors.
- **User-friendliness** of the models for third-party users.
- **Credibility** of models established by systems dynamics validation and peer-reviewed publications.
- **Collaboration** through use of existing models and engagement with academics and the industry.

❑ FY20 Milestones

Milestone Description	Month/Year	Status
MA3T-TruckChoice progress report: describing fleet segmentation and fuel economy variation	12/31/2019	Complete
MA3T progress report describing implementation of loss aversion in nested logit	03/31/2020	Complete
MA3T New Version: with data update, calibration, validation, plug-in inconvenience and learning and scale economy synergy	06/30/2020	On schedule
TEEM models progress report including work on MA3T, MA3T-TruckChoice and MA3T-used	09/30/2020	On schedule

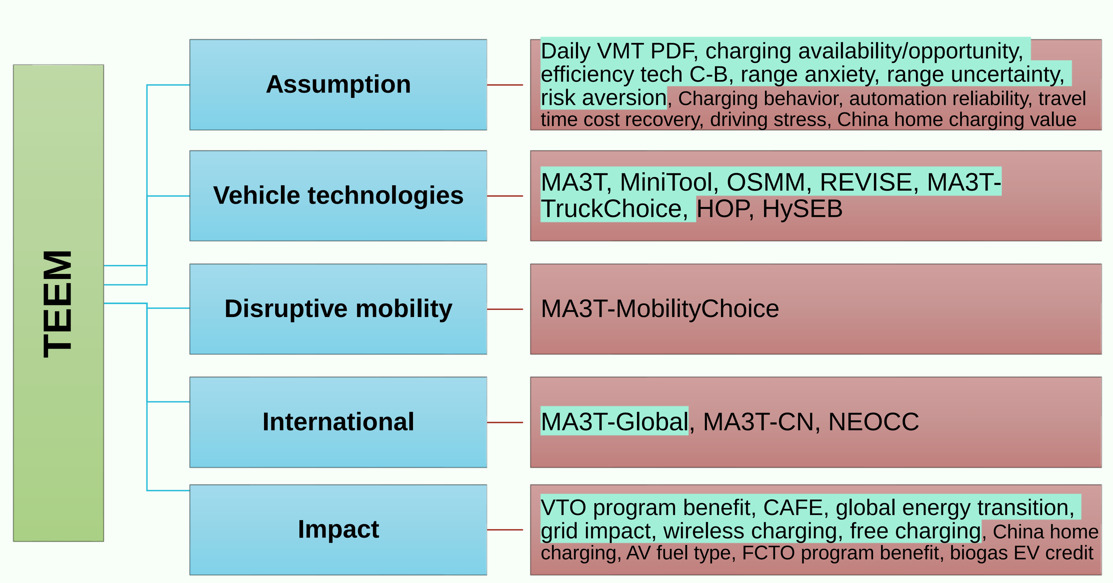
Approach

❑ Quantify/simulate assumption-impact linkages with systems dynamics models



TEEM = Transportation Energy Evolution Modeling

❑ Organization of TEEM research activities



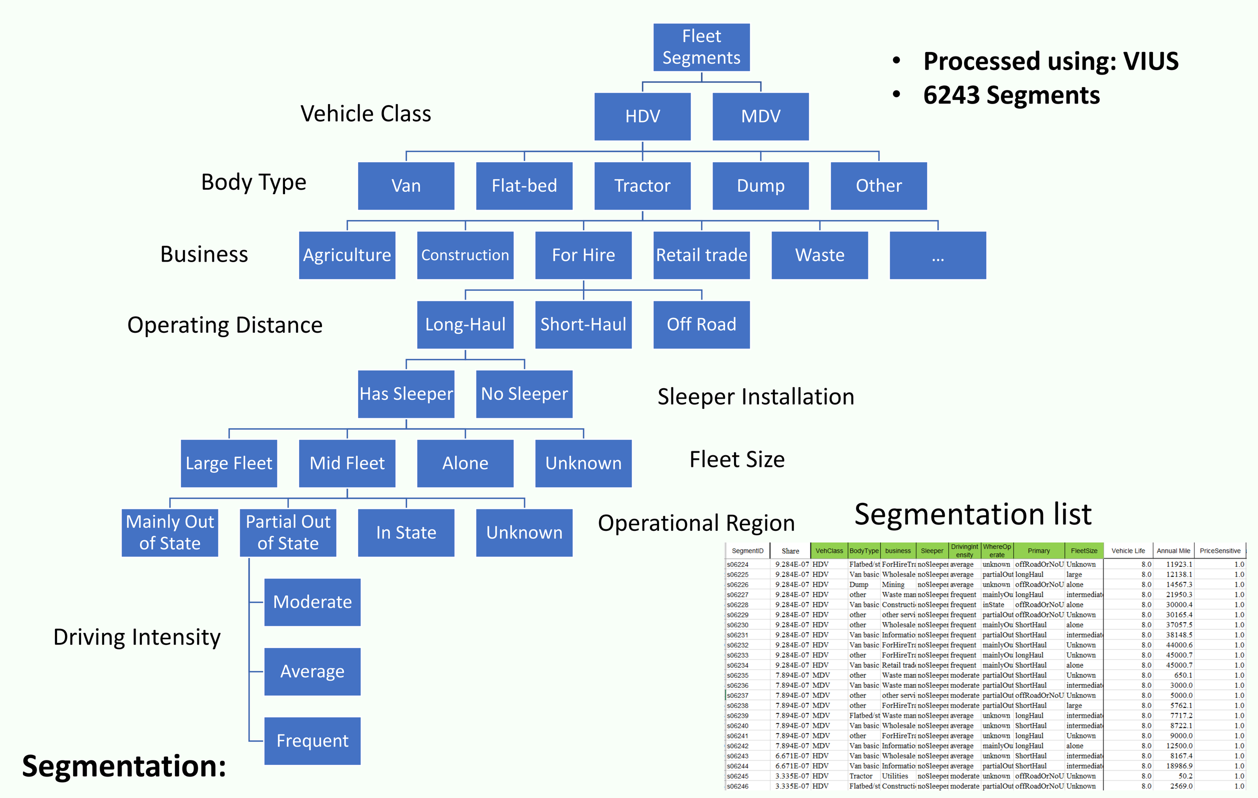
Note: Highlighted models and studies marked as are directly supported by VTO Analysis.

For example, consider a new study of cost-benefit of charging infrastructure investment (impact). If the technology scope is focused on traditional vehicle technologies, MA3T can be used. If disruptive mobility technologies such as AV are of interest, MA3T-MobilityChoice can be used. If international scope is of interest, MA3T-Global can be used. In all cases, the assumptions on charging availability/opportunity linkage and daily VMT PDF should be formulated, analyzed and validated (the TEEM group has published papers on these issues).

Truck-Choice Model

❑ MA3T-TruckChoice: Fleet Segmentation

- Processed using: VIUS
- 6243 Segments



❑ MA3T-TruckChoice: Fuel Economy Variation

- Based on literature, four factors may vary between segments and contribute to fuel economy variations. These four factors are: **operational duty cycle, typical payload level** (%), **tonnage in payload**, and **empty rate**.
- The purpose of an MHDV is to transport goods or people and the efficiency of the movement is more important than the fuel economy measurement itself.
- Thus for MHDVs, fuel economy should be evaluated with freight movement metrics, and should consider payload-specific units such as gallons per ton-mile or gallons.
- For example, the ton-mile-based fuel consumption rate could be estimated at:

$$\frac{(1-\alpha)GPM_{Typical} + \alpha GPM_{Empty}}{(1-\alpha)Payload_{Typical}}$$

Truck empty rate (%, percentage of miles with empty loads)

Fuel consumption (GPM) for empty payload

Fuel consumption (GPM) for typical payload

MA3T with Loss Aversion

❑ Background and Motivation

- Loss aversion is the tendency for individuals to weight losses more heavily than equivalent gains in decision making under uncertainty. There is substantial evidence that, on average, losses count approximately twice as much as gains.
- In this project, loss aversion broadly includes several types of behavior, including endowment effect(Kahneman et al., 2018), status quo bias (Samuelson & Zeckhauser, 1988) and the more narrowly defined loss aversion for energy efficiency (Greene, 2011)

❑ Objectives

- To capture the well-studied and empirically demonstrated loss aversion behavior
- To simulate the "tipping point" of PEV market penetration and explore the circumstances

❑ Method

- Modify MA3T to represent loss aversion in a comprehensive, flexible and coherent framework
  - $GC_i = LA_i + \sum_{j=1}^{m} X_{ij}$
  - $LA_i = \sum_{j=1}^{m} k_j \cdot max(X_{ij} - X_{0j}, 0)$

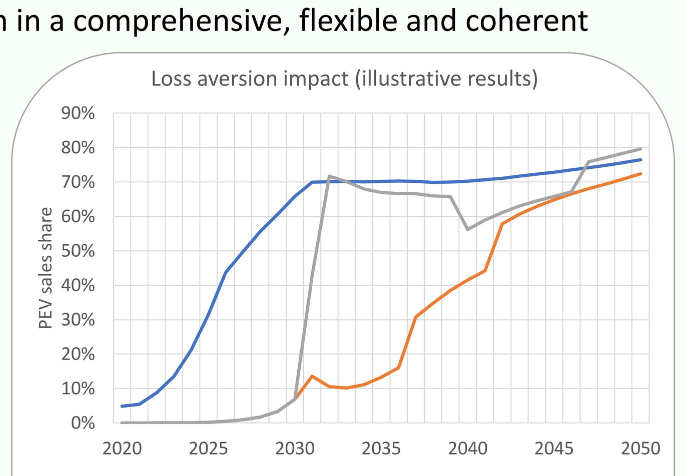
❑ Progress and Results

- Established a framework to implement loss aversion in MA3T
- Completed major code revision
- Generated illustrative results

❑ Next Steps

- Review empirical studies
- Specify loss weight coefficients
- Conduct scenario analysis
- Analyze electrification "tipping point"

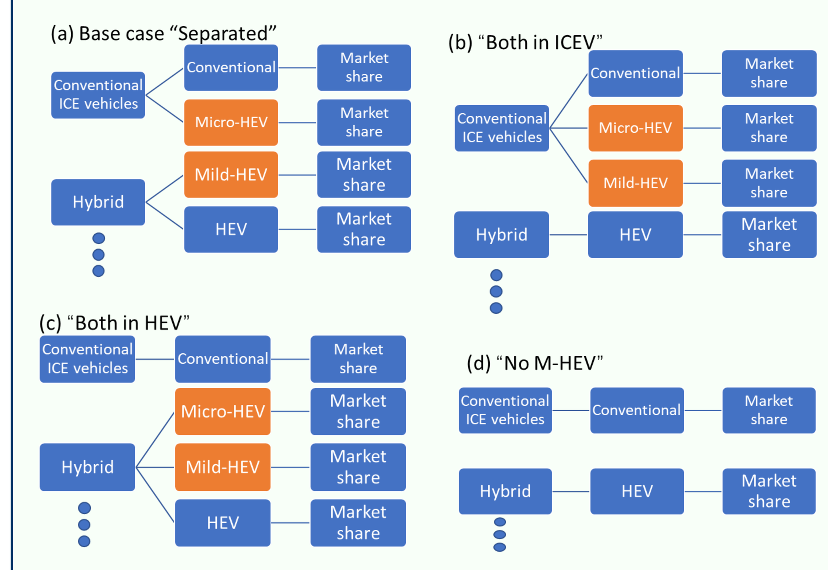
Loss aversion impact (illustrative results)



- Scenario definition
  - NoLA: no loss aversion considered
  - LA10: LA reference switch at 10% sales share
  - LA30: LA reference switch at 30% sales share
- Reference switch away from gasoline vehicles
  - LA10: BEV200 for SUV in 2030, PHEV10 for cars in 2031
  - LA30: PHEV10 for cars in 2036, PHEV10 for SUV in 2041
- Key message: understanding reference switch is critical for predicting the electrification tipping point.

Impacts of Micro/Mild-Hybrids

❑ Quantifying the Impacts of Micro/Mild-Hybrid Vehicle Technologies (M-HEV) on Fleetwide Fuel Economy and Electrification



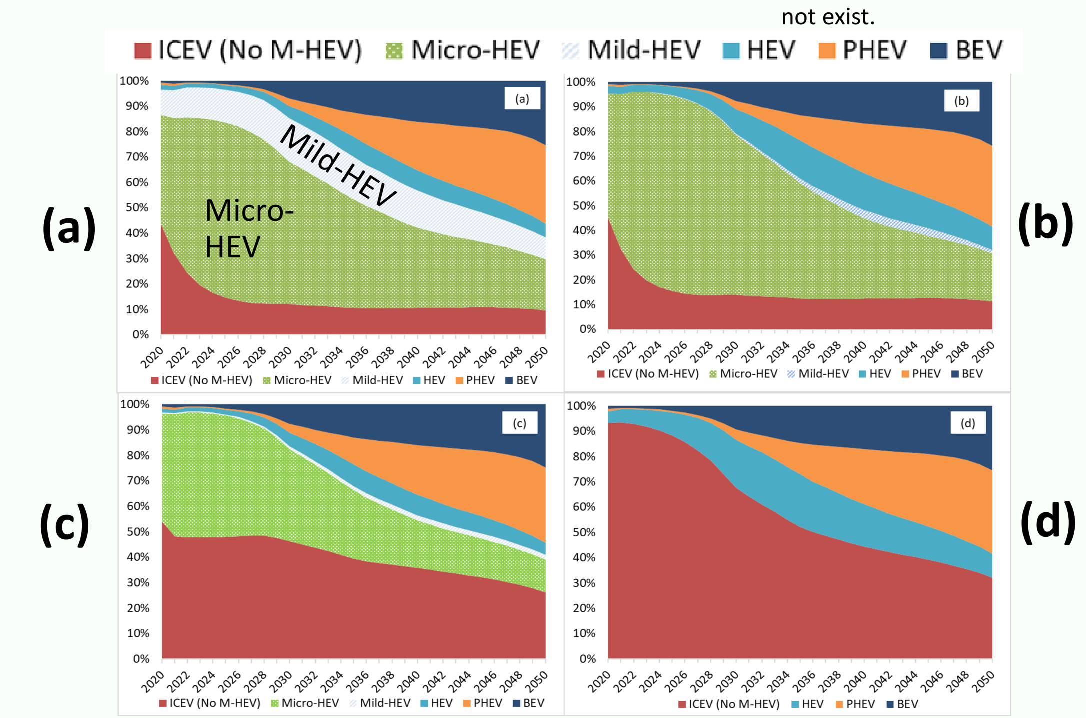
Four scenarios:

(a) Base case "Separated": Micro-HEV in the conventional ICEV choice nest, and mild-HEV in the full hybrid vehicle nest.

(b) "Both in ICEV": Both the micro-HEV and the mild-HEV are placed in the conventional ICEV nest.

(c) "Both in HEV": Both the micro-HEV and the mild-HEV are positioned within the hybrid vehicle choice nest.

(d) "No M-HEV": M-HEV is not explicitly included as if the M-HEV technology does not exist.



❑ Conclusions:

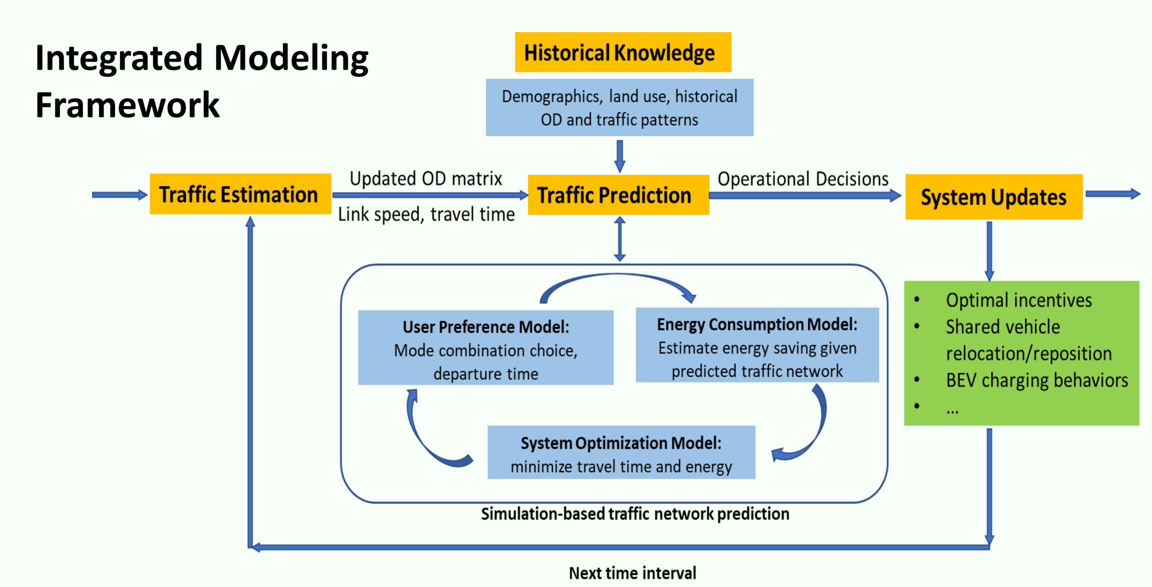
- M-HEVs are likely to dominate the engine-based powertrain market in the next decades. Outside PEVs, micro-HEVs appear to be most competitive.
- In the long-term (after year 2025), M-HEVs seem to have limited adverse effects on market growth of PEVs.
- Between 2019-2025, the industry fleetwide fuel economy in conventional internal combustion engine-based vehicles increases by 0.2-0.6 MPG.

TransitMo: Impacts of Shared Mobility

❑ TransitMo: An Integrated Microsimulation Model

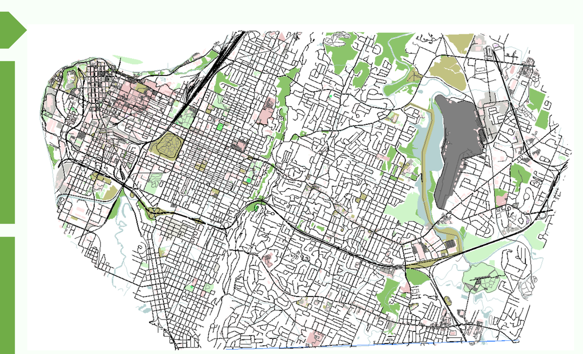
Simulates regional experience of people and goods movement based on results from microscopic simulation models; optimizes multimodal operations (cars, TNCs, transit and biking) with the first case study in the Chattanooga region

Integrated Modeling Framework



Model Development

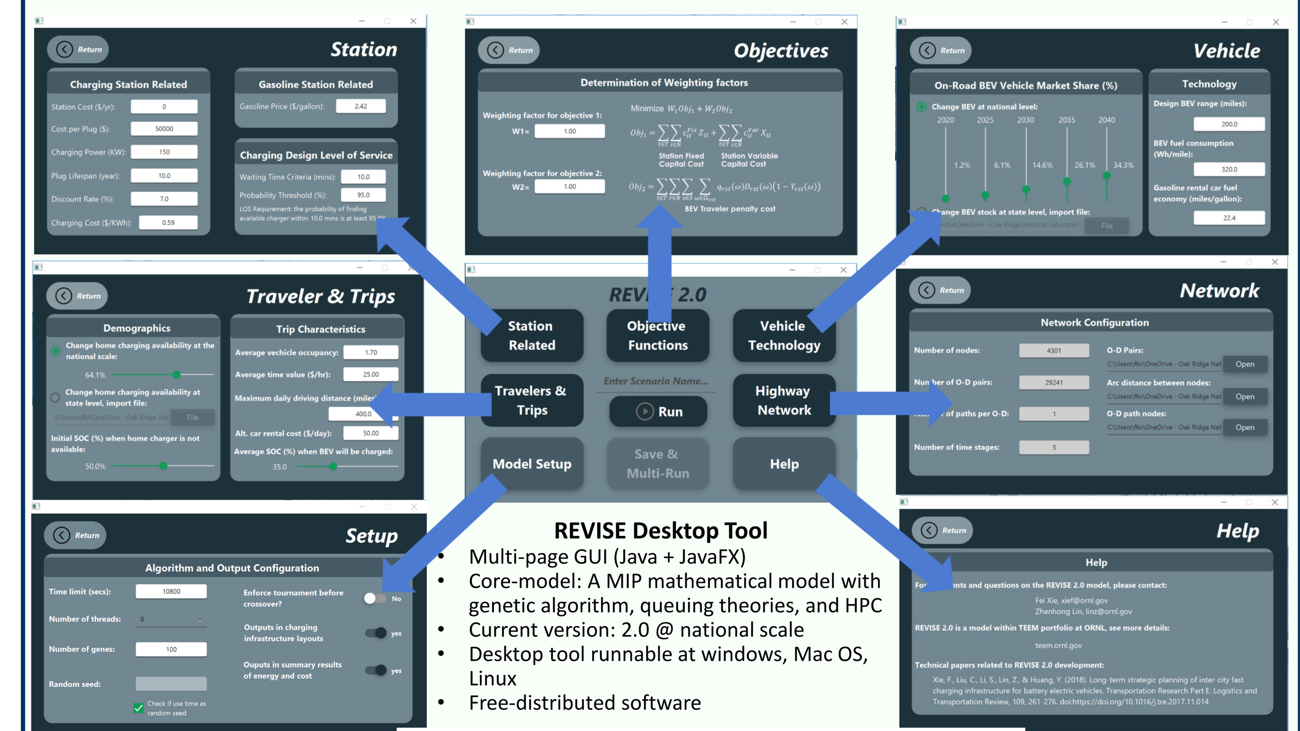
	Phase 1	Phase 2	Phase 3
TASKS	DATA COLLECTION: Demographics; Land use; Social media activities; Historical traffic patterns; Real-time traffic conditions	TRAVEL PLANNING: Vehicle fuel type (gasoline or BEVs); By automation level (human-driven or automated); Vehicle size	OPERATIONAL DECISIONS: Vehicle reposition; EV Charging behaviors; Taxi matching and routing; Bus routing scheduling; Land use planning; ...
Objective	Build multi-model large-scale simulation network (Chattanooga; NYC); Calibrate simulation network	Examine different scenarios: market penetration of EV and CAV from low to high. Collect real-world data and further validate the model.	Minimize system cost; Maximize user utility



Simulation network of Chattanooga TN in SUMO

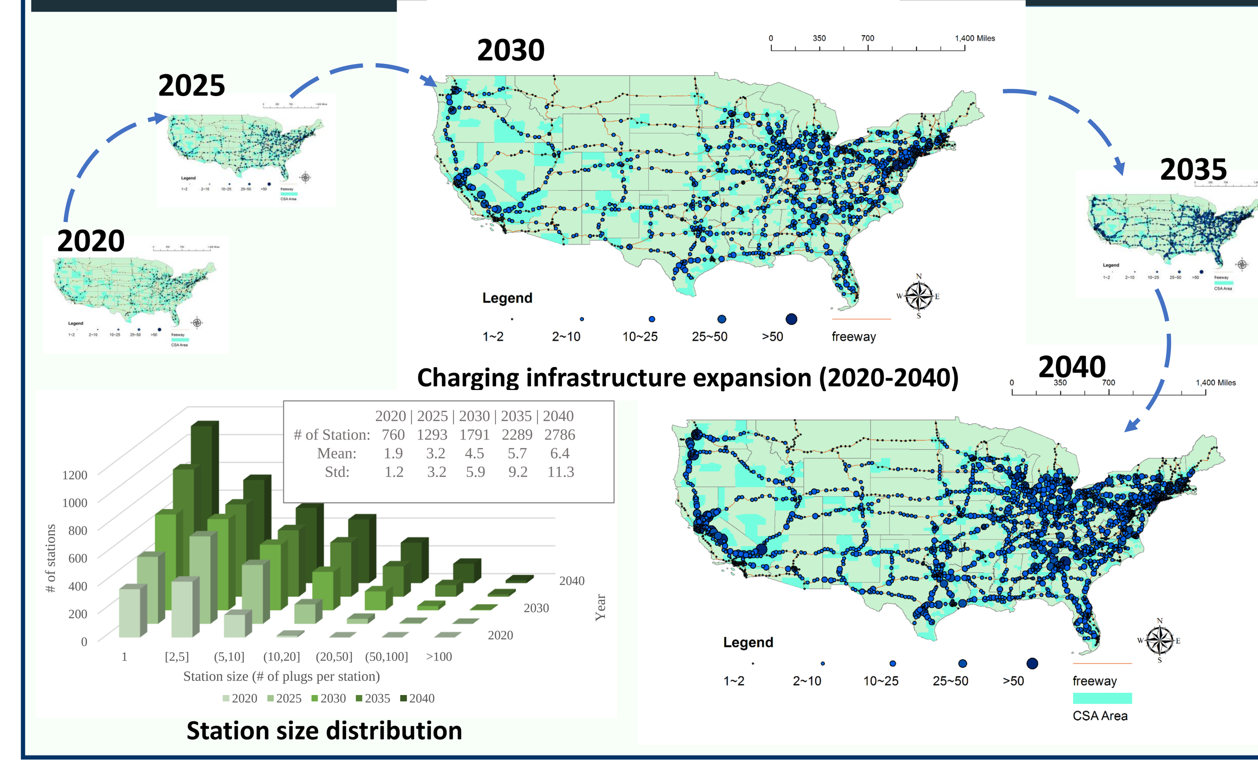
REVISE: Corridor Charging Infrastructure

❑ Regional Electric Vehicle Infrastructure Strategic Evolution (REVISE) Model



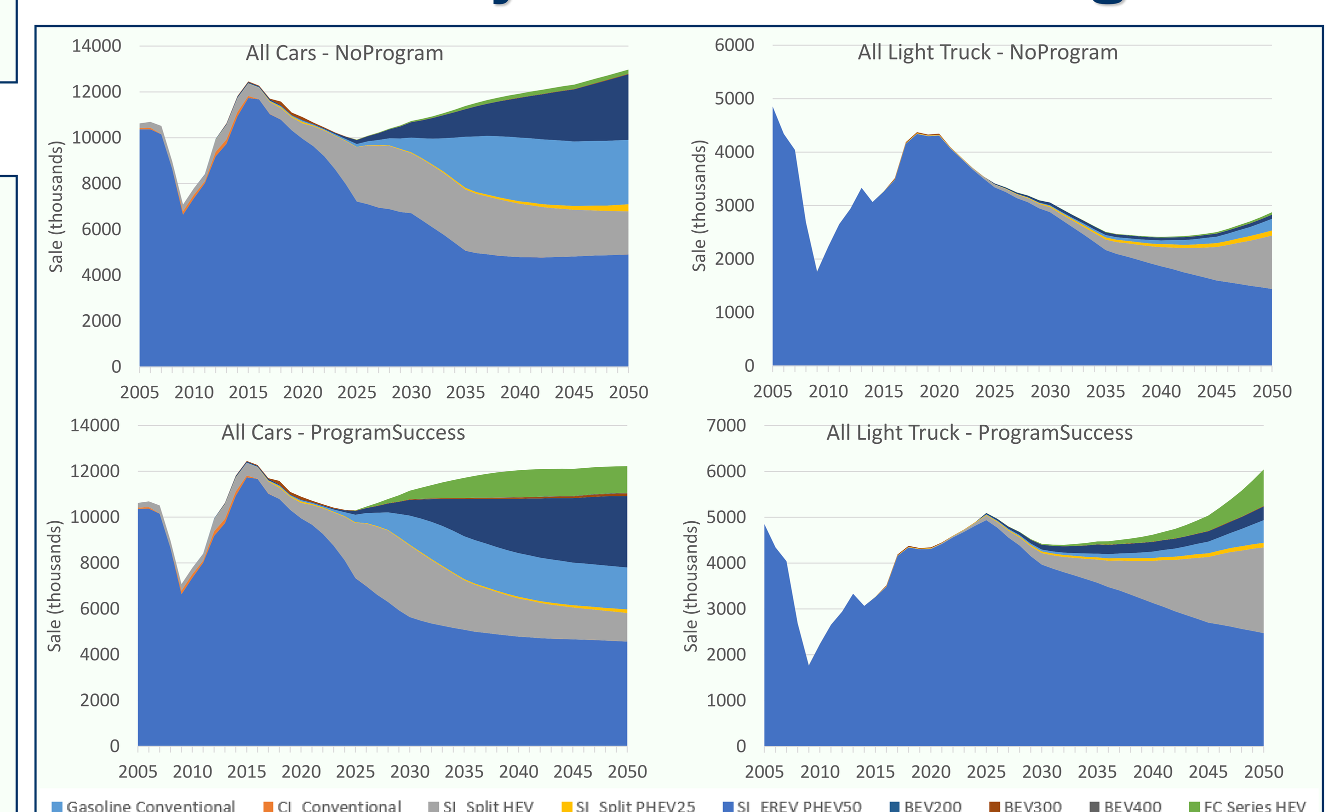
REVISE Desktop Tool

- Multi-page GUI (Java + JavaFX)
- Core-model: A MIP mathematical model with genetic algorithm, queuing theories, and HPC
- Current version: 2.0 @ national scale
- Desktop tool runnable at windows, Mac OS, Linux
- Free-distributed software



	2020	2025	2030	2035	2040
# of Station:	760	1293	1791	2289	2786
Mean:	1.9	3.2	4.5	5.7	6.4
Std:	1.2	3.2	5.9	9.2	11.3

Benefit Analysis with VTO Technologies



Summary

❑ The ORNL TEEM project includes several models useful for analysis of transportation energy issues: MA3T, MA3T-TruckChoice, TransitMo, Revise, MA3T-MobilityChoice, etc.

❑ The TEEM team has published 16 journal articles during FY19-20. manuscripts are available for download at TEEM.ORNL.GOV

❑ We are grateful for the sponsorship and support of the DOE VTO Analysis office.